E-Z Remote
Technical Report

SD1107

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Introduction:

The Device

The E-Z Remote is a device which can control several electronic devices. Originally the remote is designed for Tyler who has cerebral palsy but with slight modifications to the user interface it can serve any person with physical disabilities. This is the fourth attempt to design a device for Tyler and we are glad that it is being delivered to him this time. Currently the remote can control devices like TV, DVR, lamp, fan and others. The design also comprises a built-in radio for entertainment and a side lit acrylic display on the top of the enclosure. The remote has a simple user interface; the user can control everything with just two input buttons and any kind of head button with a 3.5 mm jack interface can be used. The buttons can be easily mounted on a wheel chair and can be used with the head as well. It works with a simple battery configuration, there are two battery compartments for more efficiency but it can also run off a power adapter. When the power adapter is used, the battery is automatically shut off. Figure 1 shows the final product.

Figure 1

The problem

In today's era, almost everything is electronic and controlling all these devices is not easy for persons with physical disabilities and it is difficult for the care-takers to be always around. We have designed a remote that allows the user to control some daily used electronic devices which will give the user a sense of independence and reduce the some work for the care-taker. During our market research we came across many such devices but all of them were very expensive and in our design we brought down the cost by a significant margin so that it is very affordable.

Requirements:

As it was the fourth attempt to design a device for Tyler, we really wanted to give him something this time. Tyler's father wanted a device that would allow Tyler to do few basic things like watch his favorite shows and movies or switch on/off the lights on his own without anyone else's help. So our advisor listed the following requirements for us in the beginning of the semester:

- A working device which could control various other electronic devices
- Simple input options
- Audio/ visual output
- Aesthetic enclosure
- Affordable
- Mass producible
- A design that would allow improvements in the future

The Basic Design:

As Figure 2 shows, the E-Z Remote comprises:

A. RF signal and X-10 communication
B. IR modules
C. Audio output for each menu option

The remote performs three main functions: RF transmitting, IR modulation and the audio output. In addition to these features, the remote has a built-in radio and the enclosure top lit LED acrylic display. The only two inputs for the remote are: the IR sensor, which will read in the IR signal from any other remote, and our two buttons.

The menu:

	Main Menu	**Sub-Menu**	**Sub-Menu1**	**Sub-Menu2**
1.	TV	TV on/off		
		DVR on/off		
		Channel Categories	Sports	ESPN/ESPN2/WGN/Fox North/TBS
			Cartoon	Boomerang/Disney/Nickelodeon/Nickelodeon2/Family
			Outdoors	Weather/Radar/Discovery/History/Travel
			Local	Fox North/KFYR/ABC
		Channel Number	0 – 9	
		TV Volume up		
		TV Volume down		
2.	X-10	A1		
		…		
		A5		
3.	Radio	Next Station		
		Reset		
		Volume up		
		Volume down		
4.	LED Control	On/Off		
		Pattern 1		
		Pattern 2		
		Blue		
		Purple		
		Green		
5.	Device Volume	Volume up		
		Volume down		
6.	Comments	Thirsty	I am thirsty.	
		Snack	I want a snack.	
		Watching something		
		Uncomfortable		
		I like the show		

The Menu Description

This menu helps in browsing and to control the device of your choice using the two buttons. The menu will be mounted or placed in clear view of the user as a visual guide. Our system also has an audio output which tells the user which option he or she is currently on. When the user turns the E-Z Remote on, it will first place the user in the three main categories. The user must then scroll up or down to choose from the main menu by using a single press on the right button to go on the next option or left button to go on the previous option. When the user is on the option that he/she desires, the user will long press the right button. This brings him/her into the sub menu. From here the user will again scroll through the options using a single press. To go in the sub menu 1, another will be needed on the right button. From here the user can also go back to the main menu at any time by long pressing the left button.

Schematics and Technical Description:

RF (Radio Frequency) – X10 communication

A long range RF transmitter chip (TXM-315-LR) is used. The frequency band 315 MHz is used as the X-10 devices in the U.S. work at 310 MHz and this is the closest available chip. Fig. 3 shows the basic circuit of the RF chip. An op-amp is used to get the data from the PIC microcontroller as the PIC sends a 5V signal and TXM-315-LR can take 2.6-3.3 Volts. When the chip receives a data signal from the PIC, it then sends an RF signal to the X-10 receiver plugged in any wall outlet in the range of 45-50 meters from the remote.

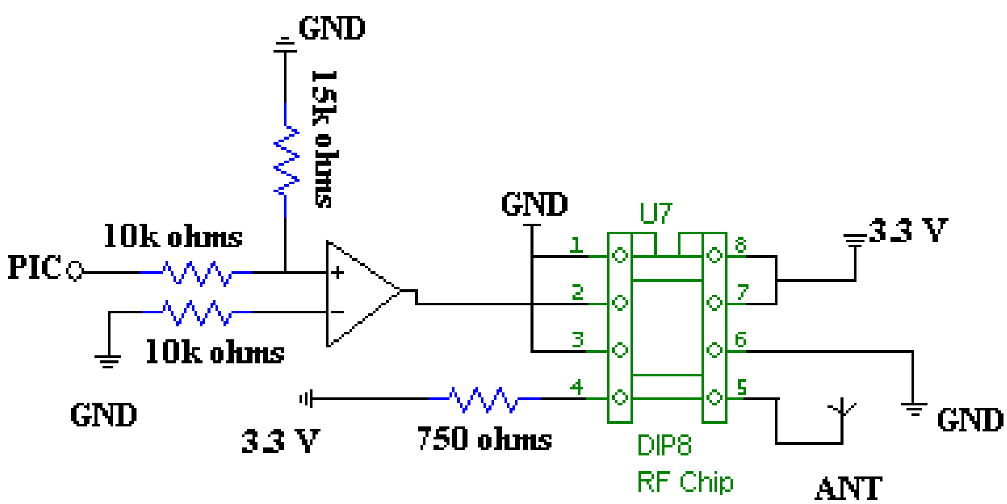


Figure 3

The X-10 receiver then communicates with the other X-10 units plugged in wall outlets via the power line. This part can be used to control the power on and off of an electronic device like; Lamp, Fan and others.

Audio Output

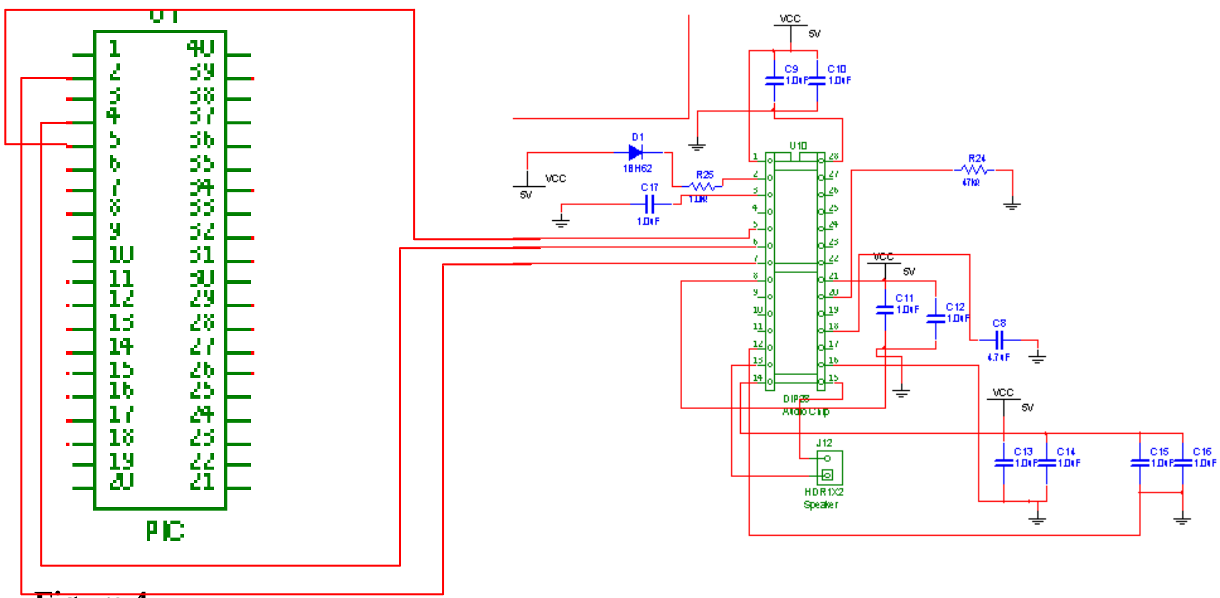


Figure 4

Figure 4 shows the connection between the PIC and the voice chip ISD17120. With the voice chip, our device is able to go through the menu items with the audio outputs. For example, if "TV" is selected, the voice "TV" will be spoken out.

- Connect pin 7(CS) of the voice chip to pin 2(CS) of the pic.
- Connect pin 6(MCLK) of the voice chip to pin 4(SCLK) of the pic.
- Connect pin 5(MOSI) of the voice chip to pin 5(MISO) of the pic.
- Varying the resistance of R24 will vary the frequency of the output from 4 kHz to 12 kHz.
- Varying the value of C8 will change the volume of the output.
- The values of the capacitors are 0.1uF.
- Speaker is connected to pin13 and 15. The speaker should be 8Ohm.
- It is better to have all the voltage supply and ground separated in order to decrease the noise.

Power Supply

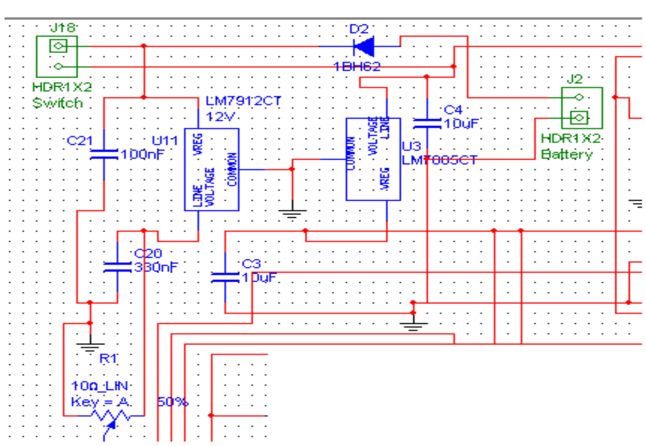


Figure 5

Our device is able to use two different power sources: battery and plug-in power supply from the wall outlets. Figure 5 shows the schematic of the power distribution.

- Once plug-in power goes into the circuit, the battery will be disabled by the diode.
- HDR1X2 switch is our device power control.
- The voltage of the battery is about 9V.
- The voltage of the plug-in power is about 17V, LM7912CT regulates it to 12V. Then LM7805CT will regulate 12V to 5V.
- If there is no voltage from the plug-in, LM7912CT stops and LM7805CT will regulate 9V to 5V. 5V is what our device need.

Infrared

- ➢ *Infrared Input Schematic*

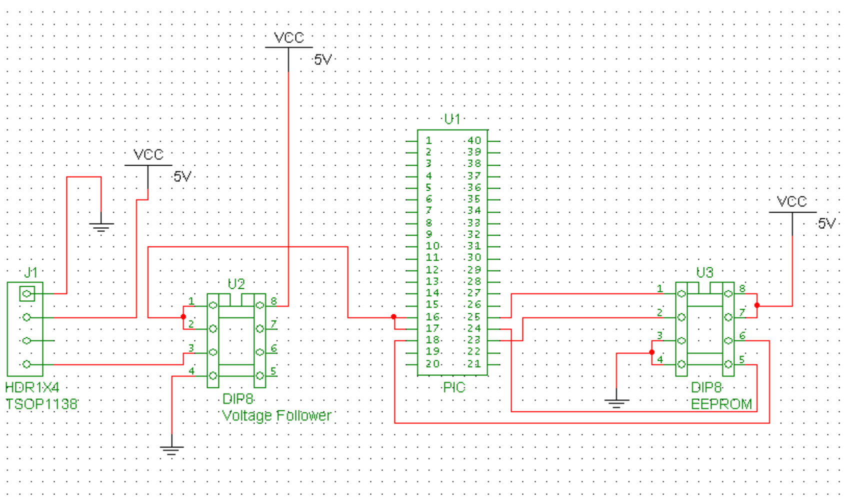


Figure 6

Above is the schematic for the Infrared input. The circuit only contains three components. Going from left to right, the first 1x4 header is for the TSOP1138 IR receiver module. The module's output pin (pin 4) outputs 5 Volts when no IR waves are exciting it. When an IR signal hits the receiver, the output pin then goes low. The output pin is then connected to a voltage follower circuit which keeps the voltage at 5 Volts when it needs to be high. Without the Voltage follower circuit, the voltage dropped to 2.5 Volts when connected to the PIC. The output of the voltage follower is then connected to two pins on the PIC. One pin connected to the PIC captures the rising edges. While the other pin connected to the PIC captures the falling edges of the IR signal coming in. These are captured using the capture interrupts in the PIC code. This incoming signal is then stored as a temporary variable on the PIC and immediately sent to an external EEPROM for permanent storage.

➢ *Infrared Output Schematic*

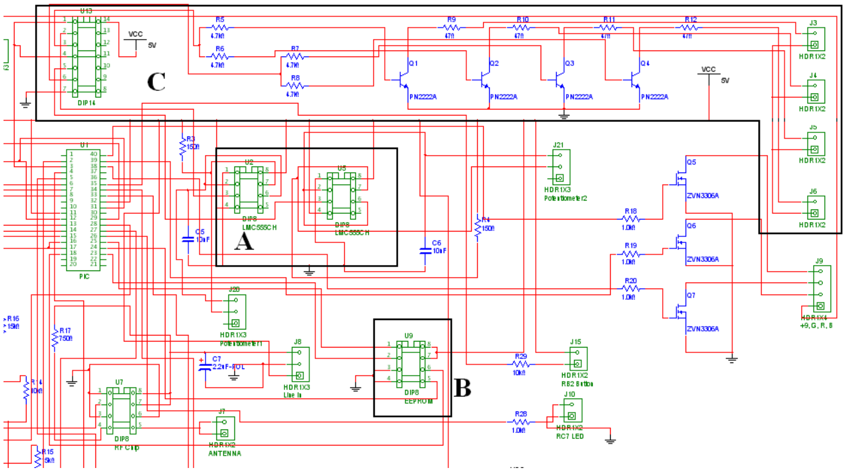
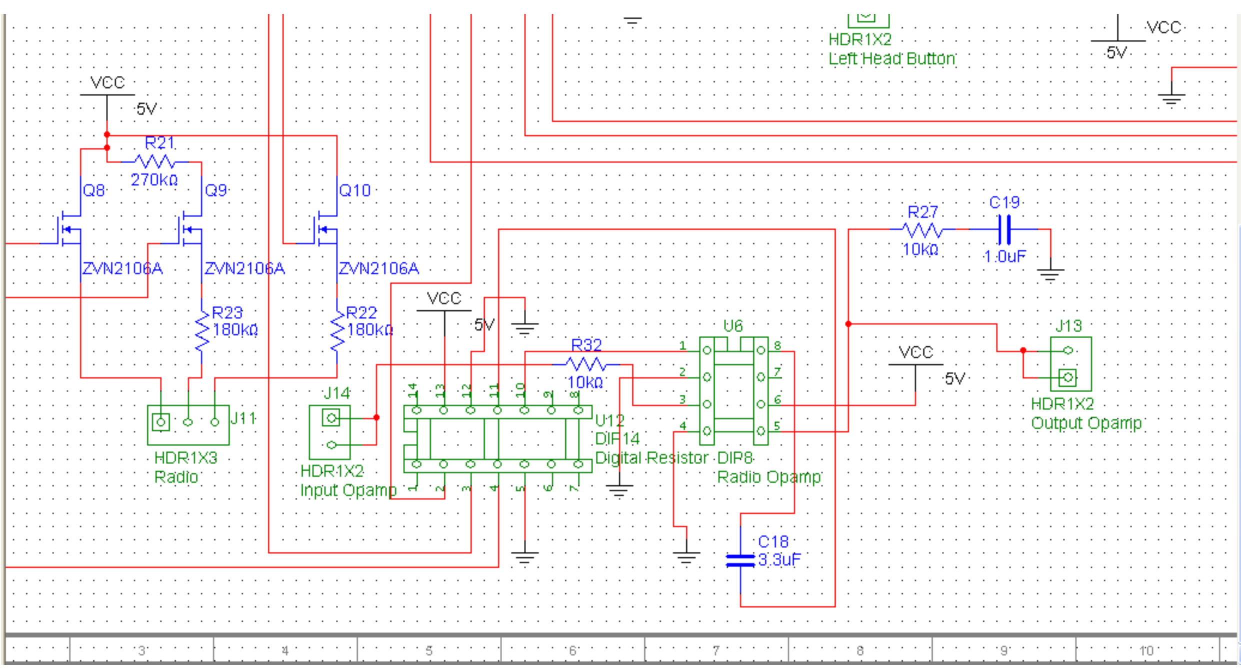


Figure 7

This is the schematic for the IR output. It consists for three sections. Section labeled A consists of two 555 timers, TLC555CP. The output of one timer generates a 37 kHz square wave, while the output on the other one generates a 56 kHz square wave. These outputs are each connected to one of the two inputs on a two-input AND gate using a four AND gate chip. The other input on both of these AND gates connect together and then connect to RA1 on the PIC. This is the actual signal to be transmitted. In order for the PIC to transmit though, it first retrieves the data of where each rising and falling edges are in reference to time. This information is stored on the EEPROM chip which is labeled as B in the schematic. Finally looking at C in the schematic, the output from each of the two AND gates is a modulated IR signal at 37 kHz and 56 kHz respectively. Each of these two signals then branches off into two more. At last, each of the four signals then drive an Infrared LED (two 870 nm, two 940 nm). I am using a transistor for each IR LED, the transistors act as a required buffer for sufficient current. The LEDs are connect to our PCB by the use of 1x2 headers (J3, J4, J5, J6).

Radio **(Figure 8)**



For the radio part, we brought a radio and use our microcontroller to control the scan and reset of the radio. To change the volume, we use the audio amplifier and the digital resistor to change the gain of the amplifier in order to change the volume. Figure 8 shows the schematic of the radio and PIC interface.

Radio: FM radio (88MHz – 108MHZ). The power supply goes through three MOSFETs which are connected to the ON/OFF, Scan and Reset buttons. The gates are connected to the pin 6, 7 and 8 of the microcontroller.

Amplifier: LM 386-3 low voltage audio power amplifier. Pin 2 and pin 4 connect to the ground, and pin 3 is the input which is from the radio's voice output. It can change the gain from 20 to about 180.

Digital resistor: DS 1666-10 digital resistor. The pin 11 and pin 10 are the high terminal and the wiper of the digital resistor, and connect the pin 1 and pin 8 of the amplifier. Pin 3, 4 and 5 are the Up/Down Control, Wiper Movement Control and Chip Select for Wiper Movement. The U/D input controls the direction of the wiper movement when setting the potentiometer. Toggling INC will move the potentiometer wiper by either incrementing or decrementing the counter. The device is selected when CS input is low. The current counter value is stored when CS is returned high. Figure 2 and Figure 3 shows the working of the digital resistor.

Microcontroller (PIC18F4620)

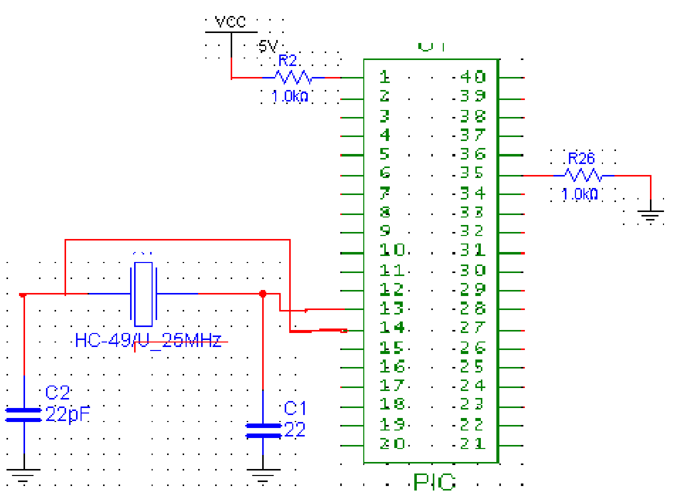
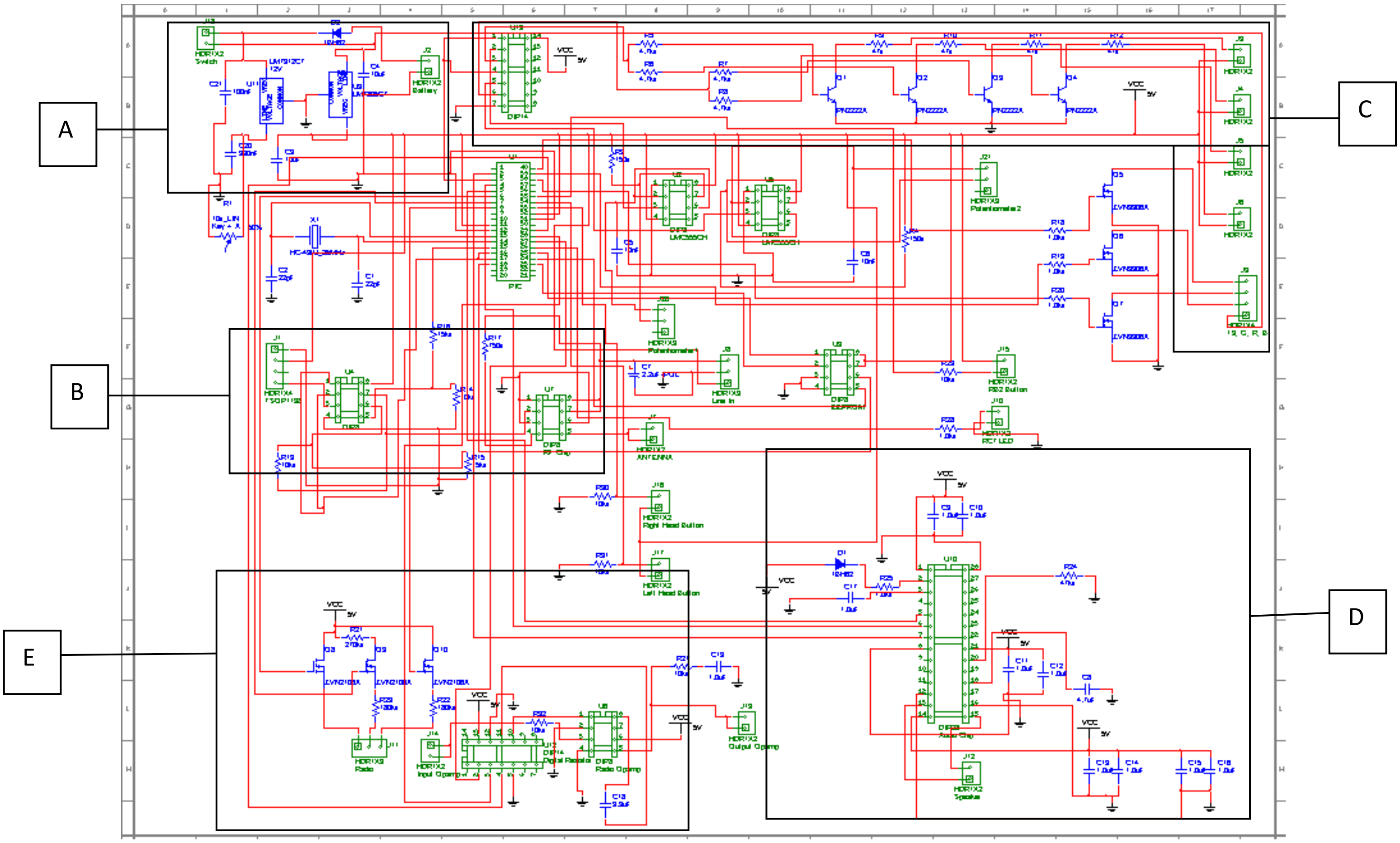


Figure 6

Figure 6 shows the schematic of the microcontroller. Our device needs the PIC microcontroller to drive and control IR circuit, RF circuits, voice chip, radio, LED, and digital resistor.

- Pin1 is connected to 5V with a 1k resistor in between. Doing this to prevent the reset of the PIC
- Pin 35 is connected to ground with a 1k resistor in between, to stop the float of the input pin RB2.
- HC-49/U_25MHz, the crystal, increases the speed of the pic. Two capacitors of 22pf connect to each side of the crystal.

The whole schematic



A: The Power Distribution

B: The RF circuit

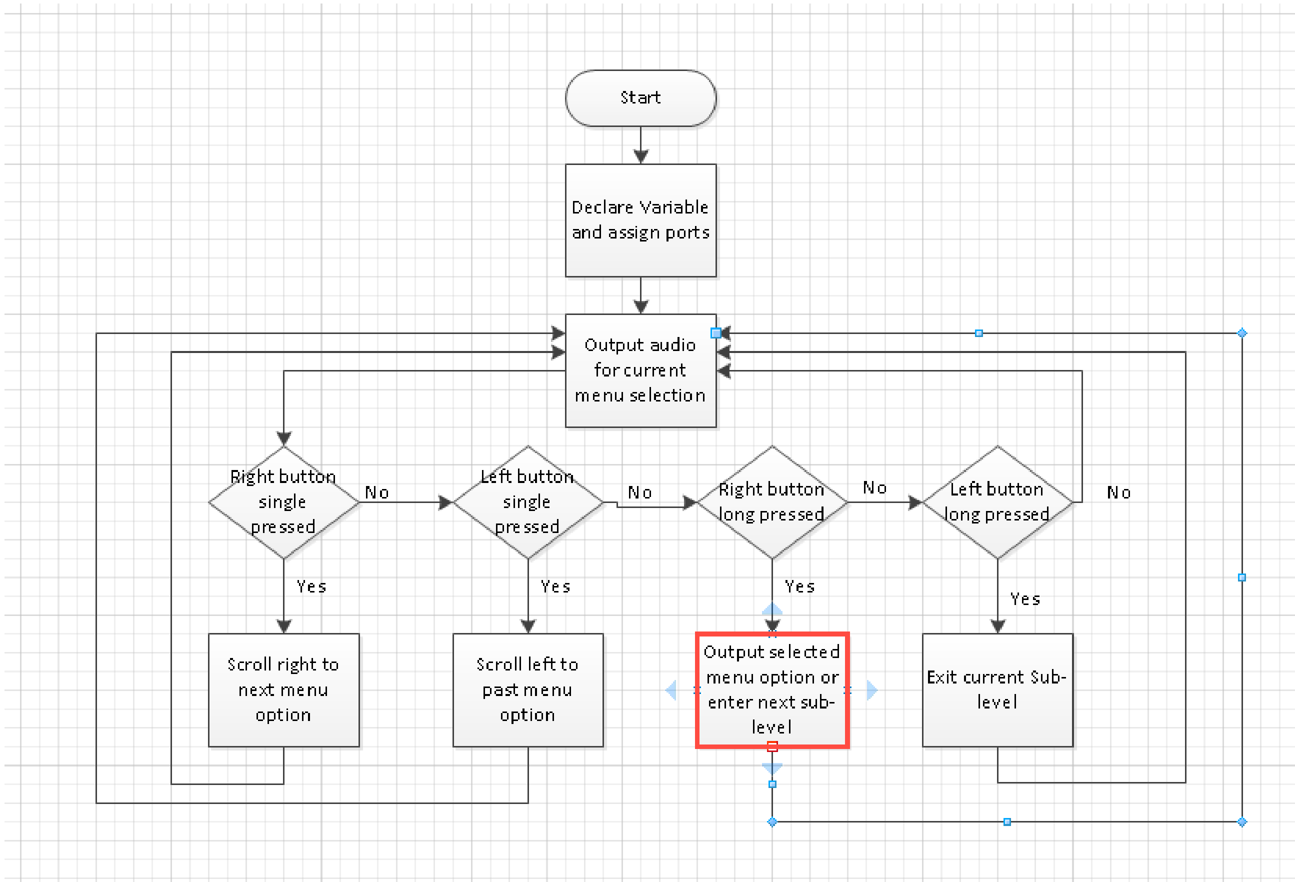
C: The IR module

D: Audio output

E: Radio

Software

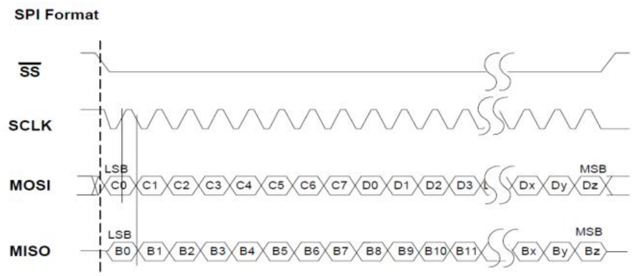
Main Program Flow Chart



Above is the flow chart for the main program. This is just the basic idea as the actual program is quite complicated and hard to describe. At startup the program will voice output "TV" as this is the first menu option. With a right button single press, the program will voice output the next menu option. With a left button single press, the program will voice output the previous menu option. With a long press of the right button, the program will either execute the current command selected or else enter the next sub-level, depending on which option is selected. With a long press of the left button, the program will exit the current sub-menu and enter the previously higher level. If the user does a long press of the left button in the main menu, then nothing will happen was there is no higher level to enter. Same goes for the right long press in the last sub-level.

Audio chip

- This is the SPI format of the voice chip.
- A SPI transaction is initiated on the falling edge of the SS pin.
- SS pin must be held low during transaction.



where Cn & Dn represent input data bit of MOSI, while Bn are output data bit.

The initial condition of the SPI inputs to the ISD1700 should be:

- SS = High
- SCLK = High
- MOSI = Low

Data is clocked into the device through MOSI pin on the rising edge of the clock signal and clocked out of the MISO pin on the falling edge of the clock signal, the LSB first.

```
unsigned char ISD_Out(unsigned char DATA)
{
    unsigned char RESULT;
    unsigned char i;
    RA2=1;
    RESULT=0;
    for(i=0;i<8; i++)
    {
        if(DATA&1)
         {
            RA3=1;
         }
       else
         {
            RA3=0;
         }
        RA2=0;
        Wait_ms(1);
        RA2=1;
        Wait_ms(1);

        RESULT=RESULT>>1;
        if(RA4)
        {
          RESULT=RESULT+0X80;
        }
        DATA=DATA>>1;
    }
 return(RESULT);
}
```

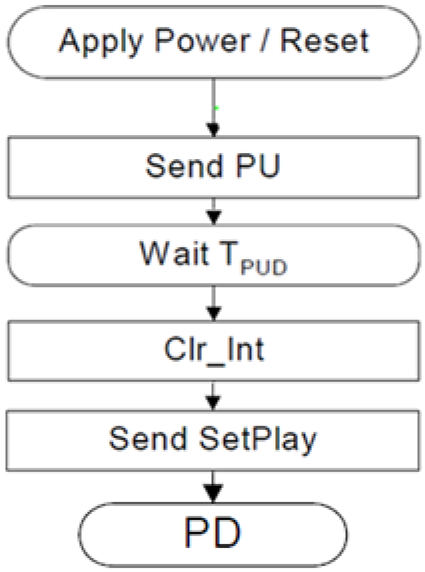
Based on the format, it makes the PIC send out eight bytes each time we run the function.

In the main function

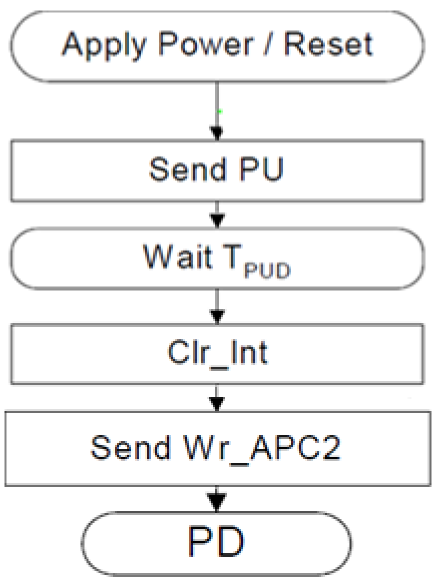
ISD_Out() can be used directly. The DATA have to be eight digits. With the combination of the function, several functions can be realized.

For our project we use Set_play function and WR_APC2 volume control. Set_Play function let us be able to randomly access the memory array by specifying the start and end address.

Flowchart for the Set_Play



Flow Chart for the WR_APC2



SS=1; SCLK=1; MOSI=0;   // initial value

Power Up:

ISD_Out(0x01);
ISD_Out(0x00);

Clr_Int:

ISD_Out(0x04);
ISD_Out(0x00);

Set_Play:

```
ISD_Out(0x80);
ISD_Out(0x00);
ISD_Out(Start);
ISD_Out(Start);  // The start address has to be 16 bytes. LSB first
ISD_Out(End);
ISD_Out(End);
ISD_Out(End);  //The end address has to 24 bytes. LSB first
```

Power Down:

```
ISD_Out(0x07);
ISD_Out(0x00);
```

WR_APC2:

```
ISD_Out(0x65);
ISD_Out(Volume); // Volume is 8 level. The volume level address is cycling. For example, 0x00=0x08.
ISD_Out(0x04);
```

The minimum length of voice that can be recorded is 125ms. For ISD17120 chip, 120/0.125=960. 960(Decimal) = 3C0 (Hexadecimal) and the first fifteen address is prerecorded, so the voice address can vary from 0x0000 to 0x03CF.

Technicians Troubleshooting

Problem	**What to Do**
E-Z Remote is unresponsive	• Make sure unit is turned on • Make sure button jacks are properly connected to main enclosure • Replace battery if necessary • If using the power adapter, make sure it is connected properly to both enclosure and the wall outlet
E-Z Remote doesn’t control X10 module	• Make sure X10 modules are set to the correct channel • Make sure X-10 modules are connected properly in the wall outlet
E-Z Remote doesn’t control IR device	• Reprogram that option for the IR device using the program button on the enclosure
E-Z Remote is not outputting audio	• Try turning the device off and then on again • Check the speaker • Replace battery if necessary
Radio is not working	• Check the radio speaker • Try repowering the remote

Project Comments

Enclosure

- A (9 X 6 inches) plastic box
- Two 9 V battery compartments
- Power jack for power from wall outlet
- A LED lit acrylic display on top
- Very user friendly
- Two large input buttons

Appendix

Cost

Already Purchased	Acquired Cost	Actual Cost
Voice Chip ISD17120PY	$7.53	$7.53
Large speaker	Free From Jeff	$2.45
Small speaker	Free From Jeff	$1.56
PIC 18F4620	Free From Jeff	$7.94
TLC555JVFM (x2)	Free From Jeff	$0.50
Linux TXM-315-LR	$7.46	$7.46
25AA1024 EEPROM	$4.40	$4.40
ZTX849 (x6)	Free From Jeff	$7.54
P2N2222A (x4)	Free From Jeff	$1.44
IR LED (x4)	Free From Jeff	$0.96
3K Potentiometer (x2)	Free From Jeff	$1.99
SN74HC08N AND Gate	Free From Jeff	$0.16
20 MHz crystal	Free From Jeff	$0.31
MCP602	Free From Jeff	$0.62
Voltage Regulators (x3)	Free From Jeff	$2.99
DS1666-010 Digital Resistor	Free From Jeff	$1.99
Radio Board	$4.89	$4.89
LM386N3 Audio Amplifier	Free From Jeff	$0.91
Miscellaneous switches and jacks	Free From Jeff	$9.99
Various Capacitors and Resistors	Free From Jeff	$4.99
Large Head Buttons (x2)	Free From Last Group	Unknown
9 Volt Batteries (x2)	Free From Jeff	$4.72
12 Volt DC transformer	Free From Jeff	$5.99
X-10 devices	Free From Last Group	$20.30
Total	**24.28**	**$102.63**

The cost of the PBC is not included in the above total cost. The PCB costs $ 60 so the total cost including the X-10 modules will be **$162.63**.

PCB Layouts